

monthly amount, 5.28, occurred at Plattsburg Barracks, and the least, 0.05, at Mount Morris.—*R. G. Allen.*

**North Carolina.**—The mean temperature was 77.7°, or 1.7° above normal; the highest was 102°, at Southern Pines on the 3d and at Saxon on the 20th, and the lowest, 47°, at Linnville on the 16th. The average precipitation was 4.18, or 1.60 below normal; the greatest monthly amount, 14.19, occurred at Hatteras, and the least, 0.65, at Soapstone Mount.—*C. F. von Herrmann.*

**North Dakota.**—The mean temperature was 65.5°, or 0.6° below normal; the highest was 97°, at Medora on the 25th, and the lowest, 32°, at Foxholm and Hamilton on the 13th, Woodbridge on the 29th, and Minto on the 31st. The average precipitation was 2.90, or 1.32 above normal; the greatest monthly amount, 7.80, occurred at Fullerton, and the least, 0.24, at Melville.—*B. H. Bronson.*

**Ohio.**—The mean temperature was 73.7°, or 2.5 above normal; the highest was 104°, at Warsaw on the 20th, and the lowest, 39°, at Wooster on the 7th. The average precipitation was 1.82, or 1.26 below normal; the greatest monthly amount, 6.26, occurred at New Paris, and the least, 0.15, at Plattsburg.—*J. Warren Smith.*

**Oklahoma.**—The mean temperature was 85.6°, or 6.2 above normal; the highest was 113°, at Kemp on the 26th, and the lowest, 59°, at Pawhuska and Prudence on the 29th. The average precipitation was 0.87, or 2.29 below normal; the greatest monthly amount, 3.18, occurred at Perry, while none fell at many stations in the south and west.—*J. I. Widmeyer.*

**Oregon.**—The mean temperature, 60.6°, the lowest on record, was 5.0° below normal; the highest was 97° at Pendleton on the 4th, and the lowest, 16°, at Riverside on the 14th. The average precipitation, 2.42, was 1.84 in excess of the normal, and was the heaviest on record; the greatest monthly amount, 8.13, occurred at Nehalem, and the least, 0.08, at Klamath Falls.—*B. S. Pague.*

**Pennsylvania.**—The mean temperature was 71.2°, or 1.6° above normal; the highest was 101°, at Huntingdon on the 21st, and the lowest, 33°, at Shingle House on the 9th. The average precipitation was 4.01, or 0.33 above normal; the greatest monthly amount, 10.09, occurred at Carlisle, and the least, 0.07, at Erie.—*T. F. Townsend.*

**South Carolina.**—The mean temperature was 81.2°, or 2.6° above normal; the highest was 103°, at Batesburg and Beaufort on the 6th, and the lowest, 59°, at Santuc on the 18th. The average precipitation was 6.26, or about normal; the greatest monthly amount, 17.94, occurred at Pinopolis, and the least, 1.33, at Cheraw.—*J. W. Bauer.*

**South Dakota.**—The mean temperature was 71.4°, or about 1.0° above normal; the highest was 104°, at Interior on the 16th, and the lowest, 30°, at Rochford on the 24th. The average precipitation was 3.55, or about 1.06 above normal; the greatest monthly amount, 9.56, occurred at White Swan, and the least, trace, at Farmingdale.—*S. W. Glenn.*

**Tennessee.**—The mean temperature was 79.2°, or 3.6° above normal; the highest was 103°, at Covington on the 13th, and the lowest, 51°, at Erasmus on the 19th and at Silverlake on the 24th and 25th. The

average precipitation was 2.47, or 1.03 below normal; the greatest monthly amount, 5.68, occurred at Tracy City, and the least, 0.31, at Union City.—*H. C. Bate.*

**Texas.**—The mean temperature, determined by comparison of 46 stations distributed throughout the State, was 3.1° above the normal; there was a general excess in temperature for the month, ranging from 1.0° to 7.0°, with the greatest over the northwest portion of the State; the highest was 112°, at Mann on the 23d, and the lowest, 56°, at Marathon on the 30th. The average precipitation, determined by comparison of 53 stations distributed throughout the State, was 1.97 below the normal; there was a slight excess in the vicinity of Beaumont and Houston, while there was a general deficiency elsewhere, ranging from 1.00 to 3.33, with the greatest deficit over southwest Texas. The rainfall for August was light and very unevenly distributed over the State. The greatest monthly amount, 5.95, occurred at Jasper, while none fell at many stations over the western half of the State.—*I. M. Oline.*

**Utah.**—The mean temperature was 65.7°, or 5.2° below normal; the highest was 102°, at St. George on the 31st, and the lowest, 24°, at Croydon on the 23d. The average precipitation was 0.96, or 0.27 above normal; the greatest monthly amount, 2.93, occurred at St. George, while none fell at Terrace. It was the coolest August in Utah of which there is any record.—*L. H. Murdoch.*

**Virginia.**—The mean temperature was 75.5°, or about 0.5° above normal; the highest was 102°, at Farmville on the 5th, and the lowest, 42°, at Burkes Garden on the 24th. The average precipitation was 4.62, or 0.25 above normal; the greatest monthly amount, 8.81, occurred at Fontella, and the least, 1.39, at Burkes Garden.—*E. A. Evans.*

**Washington.**—The mean temperature was 60.8°, or about 5.0° below normal; the highest was 100°, at Lind on the 3d, and the lowest, 30°, at Cle-Elum on the 28th. The average precipitation was 2.24, or about three to four times the normal; the greatest monthly amount, 5.77, occurred at Snohomish, and the least, 0.23, at Connell. The month was phenomenally cool and wet, breaking all records of August for low temperature and excessive precipitation.—*G. N. Salisbury.*

**West Virginia.**—The mean temperature was 73.5°, or 1.2° above normal; the highest was 100°, at New Cumberland on the 20th, and the lowest, 34°, at Terra Alta on the 7th. The average precipitation was 2.64, or 0.92 below normal; the greatest monthly amount, 6.37, occurred at Madison, and the least, 0.34, at Romney.—*C. M. Strong.*

**Wisconsin.**—The mean temperature was 70.5°, or 2.6 above normal; the highest was 98°, at Brodhead on the 27th, and the lowest, 37°, at Butternut on the 6th. The average precipitation was 3.27, or 0.69 above normal; the greatest monthly amount, 7.40, occurred at Prentice, and the least, 0.36, at Green Bay.—*W. M. Wilson.*

**Wyoming.**—The mean temperature was 63.0°, or 2.7° below normal; the highest was 101°, at Lovell on the 1st, and the lowest, 20°, at Burns on the 22d and 23d. The average precipitation was 0.82, or 0.06 below normal; the greatest monthly amount, 2.23, occurred at Fort Yellowstone, and the least, trace, at Buffalo.—*W. S. Palmer.*

## SPECIAL CONTRIBUTIONS.

### WATERSPOUTS AT KEY WEST, FLA.<sup>1</sup>

By H. R. BOYNTON, Observer, Weather Bureau (dated May 26, 1899.)

Seven waterspouts were observed simultaneously, by myself, on the morning of May 26, 1899, at Key West, Fla. They were at an estimated distance of two miles and moving from north to south. Four were well defined and three others plainly outlined. The four fully formed one would sometimes disappear, when others would form and take their places. The procession of whirlwinds moved slowly, thus furnishing an unusually good opportunity for observing the

<sup>1</sup> Waterspouts are so common at stations on the Gulf coast that we can but hope that they may be utilized as a test of the modern thermodynamic theories of the condensation of vapor and formation of clouds. This theory was first put into definite shape by Ferrel in his *Recent Advances*, but improvement has been made in several points since then by Professor Brillouin of Paris and Prof. F. H. Bigelow of the Weather Bureau. In order to properly study the waterspout we need a series of photographs on a large scale, taken simultaneously from opposite points of view, with the modern photogrammeter, which is simply a camera so mounted as to be movable in altitude and azimuth, with means for accurately determining the direction in which it is pointed at any time. Until such a determined effort has been made to achieve a scientific study of the waterspout (and a similar one of the tornado) we must be content with the general descriptions recorded by careful observers, such as the accompanying from Mr. H. R. Boynton, which is certainly an interesting addition to our knowledge of the waterspout.—*Ed.*

gradual formation of each waterspout. A partially-formed spout would extend downward from the moisture-laden cloud, swing a short distance through space, then be drawn up into the cloud and disappear. This occurred several times; meantime others would reach down from the cloud and descend far enough to form a fully-developed spout connecting with the water below which was already in commotion caused by the influence of the whirling wind. At times the water would rise from below, seemingly outside of the main spout and half way up its trunk. At one time the cross section appeared to form a parallelogram across the main trunk, one-third of the distance from the top, and took the shape of a perfect dagger. The cross-piece had, seemingly, square corners (but a circular ring, observed from a distance, would appear like a parallelogram). This spout, which took the form of a cross, was at first a short spur not more than 3° long, and grew slowly out of the cloud at an angle of 45°. At times it had an undulatory motion. People on vessels in the vicinity say that the water forming up around the base of each column showed forth very brightly the colors of the rainbow. I observed that the sea in the vicinity showed the same characteristics but not so vividly. The cloud above the waterspout was very dark and the sea beneath looked as black as ink. At intervals throughout the forenoon there were whirlwinds in the streets here, of which I saw three at one time.

The phenomena differed notably from the description and the cuts usually given in text-books, which describe them as moving swiftly, whereas these moved slowly and vessels in their vicinity were able to avoid them. The books also picture them as tapering to a point at the lower end, but these and others like them were of the same size all the way up. The books represent the spouts as being vertical, but one-third of these had a slant of at least 60°. The one that took the form of a dagger was at first a short spur, not more than 3° long, just peeping out from an overhanging cloud at an angle of 45° and grew quite slowly.

Seven diagrams which are individually reproduced on Plates I and II. The legend at the bottom of each gives many additional particulars so that the student can easily follow the historical order of development in each waterspout.

In addition to the data here given, and in reply to a letter from the Editor, Mr. Boynton sends the following items under date of July 16:

I have a nephoscope and can estimate the field of activity pretty well, and get bearings from the angles of neighboring buildings, and I remember that the waterspouts were at nearly equal distances apart. I also feel confident that I can estimate the height of the columns with quite a degree of accuracy.

Top of columns above bases, 18°.

General width of columns, 4°.

Width of columns at top, where they opened into the cloud, 3°.

Width of columns at base, including water in commotion, 5°.

Distances of columns apart between first and second on the left, 5°; between the others, 4°.

Area of vertically falling water on the right of the field: Altitude, 18°; width, 12°; field of activity, including said area, 40°.

The greater number of the waterspouts were not tapering, like the typical waterspouts, but, except at top and bottom, were of one size all the way up. Therefore, I can not furnish largest diameter, of columns, except at top and base. But there was one notable exception; it was the curved column with a bar across it: Fig. VII.—Spout No. 6. The bar seemed to be 4° long and 1° wide.

Am not able to furnish any account from people aboard ship at the time.

The temperature of the air, etc., can be furnished with perfect accuracy, because the phenomena began just as I began the morning observation: Dry thermometer, 81.0°; wet thermometer, 74.0°; wind, north; wind velocity, 4 miles per hour.

## WATER TEMPERATURES OF THE GREAT LAKES.

By NORMAN B. CONGER, Local Forecast Official and Marine Agent.

The study of the distribution of fog on the Great Lakes, which has now been carried on for upward of two seasons, shows among other things the importance of a knowledge of the temperature of the surface water. In 1892, 1893, and 1894 the Weather Bureau collected observations of water temperatures made by masters of vessels plying between Lake ports, and in the last named year the writer was one of a small party that visited Lake Superior and made many surface observations and also a number of observations at depths of 10, 20, and 100 feet. A brief statement of the results of these observations is here given.

**Lake Superior.**—The lake closes to navigation with the closing of the St. Mary's Canal about December 1, but ice rarely forms in the open lake before the beginning of January. In some of the harbors it does not form much before February 1. Ice on the open lake may form to a thickness of from 1 to 4 feet; it is frequently piled up, however, to a much greater depth. The ice in the open lake breaks up in April and is drifted about by the winds until it finally disappears. The water temperatures in May in shallow bays average about 40°, being slightly warmer at the western end of the lake than along the shore from Marquette eastward. In the middle of the month the average temperature of the water over the great body of the lake is about 37°, being slightly lower in a few localities. In June the temperature of the surface water along shore, where the depth is not great, averages from 48° to 54°, being, as before stated, warmest at the western end of the lake. The temperature is lower toward the deeper parts of the lake, reaching a minimum of 37° in midlake, but the area of 37° is less than during the preceding month. In July the temperature of the surface water in midlake has risen to 40°, while shore temperatures have risen to 60° and over in some of the shallower bays. The difference between the temperature of the water in midlake and along shore is greatest in July and August, viz, 20° and upward. In August the area over which water temperatures of 40° occurs is less than for July and can be found only

in the center of the lake. The influence of the warmer air temperatures of June and July is now felt in the general warming up of the waters. Large areas of water show an increase in temperature from the month preceding of about 10°. The maximum temperature of the water in the great body of the lake occurs in September about a month after the highest air temperature. It is to be noticed, however, that the temperature of the water along shore has begun to fall, the maximum of the year being registered in August. During October the temperature of the water falls from 5° to 10° over the great body of the lake. Shore temperatures range from 45° to 50°, decreasing from those amounts to about 40° in deep water. In November the temperature of the water around the shore and in deep bays is about 40°, diminishing to 37° in midlake.

We have thus seen that the surface temperature of the water along shore and in the larger bays increases from 32° in winter to about 60° in August, a total range of 28°. In midlake the increase is very much less, from 32° to 40° or 45°, certainly not more than half of what it is for shore waters.

**Lake Michigan.**—The observations for the remaining lakes are not sufficiently numerous to discuss the months in detail; our remarks will apply to July only. The coldest portion of Lake Michigan is found in the center of the northern two-thirds where the mean temperature for July is 55° or less, but above 50°. Surrounding this area of relatively cool water is a region of warmer water, 60°, broken only in the north-west where the temperature of the water is about 55°. The temperature of the northeastern part of the lake is between 60° and 65°. The warmest part of the lake, as might be expected, is around the southern end where mean temperatures above 65° may be found.

Masters of vessels occasionally report low water temperatures in summer off the Michigan coast in the vicinity of Grand Haven and Muskegon. Additional observations are required before we are justified in assigning an abnormally cold area to this locality.

**Lake Huron.**—The observations on this lake are naturally confined to the west shore. The temperature of the water in July is about 65° from near Thunder Bay Island southward to near Port Huron. Colder water may be found in bands extending southeastward from the east and west ends of Drummond Island. The differences between the water temperatures along shore and some distance out in the lake are not so great as in the case of Lake Superior, nor are the differences between water and air temperatures so well marked. In July at Mackinaw the average temperature of water at the surface in a depth of about 11 feet was 63°; the average temperature at the bottom was 62°, while for the same time the average temperature of the air was 69° (average of four years).

In the Detroit River the average surface temperature for July in water 24 feet deep was 69.7°; at the bottom, 69.6°, while the air temperature for the same time was 77.7°, a difference of 8°. Probably the difference between water and air temperatures over Lakes Michigan and Huron is not more than 7°.

**Lake Erie.**—The temperature of the water in this lake approaches more closely to the temperature of the air than is the case on any other lake. Generally the mean water temperatures range between 70° and 75°.

## RECENT PAPERS BEARING ON METEOROLOGY.

W. F. R. PHILLIPS, in charge of Library, etc.

The subjoined list of titles has been selected from the contents of the periodicals and serials recently arrived in the library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

*Meteorologische Zeitschrift. Wien. Band 16.*

Danckelman, A. Ueber das Harmattanphänomen in Togo. P. 289.

Moller, A. Arbeitsvorgänge bei auf wie absteigenden Luftströmen und die Höhe der Atmosphäre. P. 306.

Polis, P. Ergebnisse der Temperaturbeobachtungen zu Aachen 1838-1897. P. 310.

Regenfall am Fusse des Kamerun-Pik. P. 312.

[Hann, J.] Schliessung des Jamaica Weather Service. P. 312.

Halo-Phänomen. P. 312.

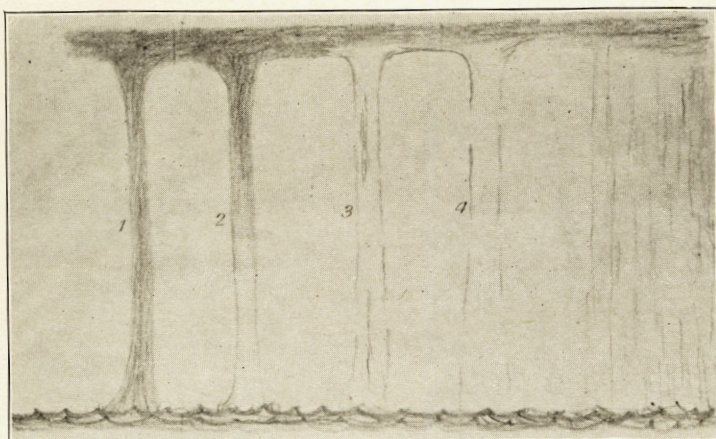
Das kalte Küstenwasser, Entdeckung der Ursache desselben. P. 313.

Klima von London. P. 314.

Scheitelwerth und Mittelwerth in tropischen Klima. P. 314.

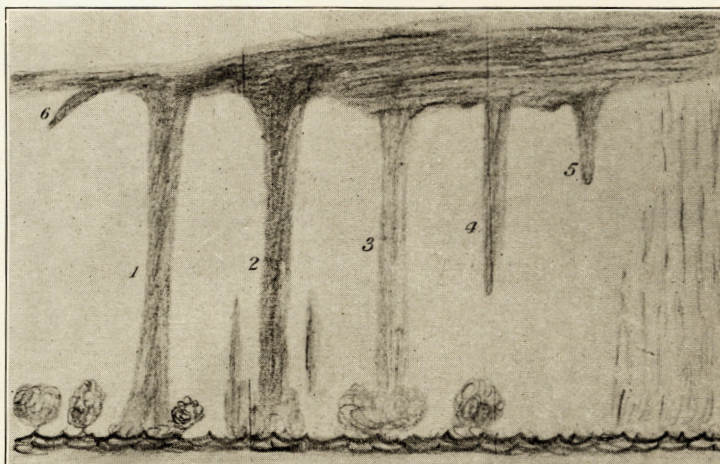
Resultate der meteorologischen Beobachtungen in der Depression im Herzen des asiatischen Kontinents, zu Luktschun bei Turfan. P. 315.

Fig. 1.—First phase, observed at 7:35 a. m.



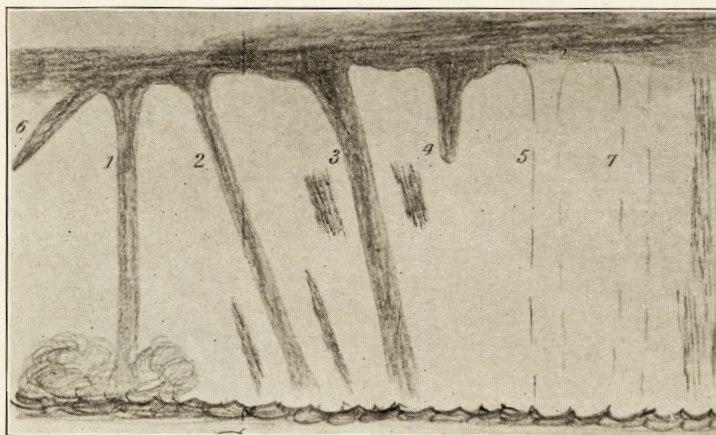
Nos. 1, 2, 3, and 4 forming at rather irregular intervals.

Fig. 2.—Second phase, observed at 7:45 a. m.



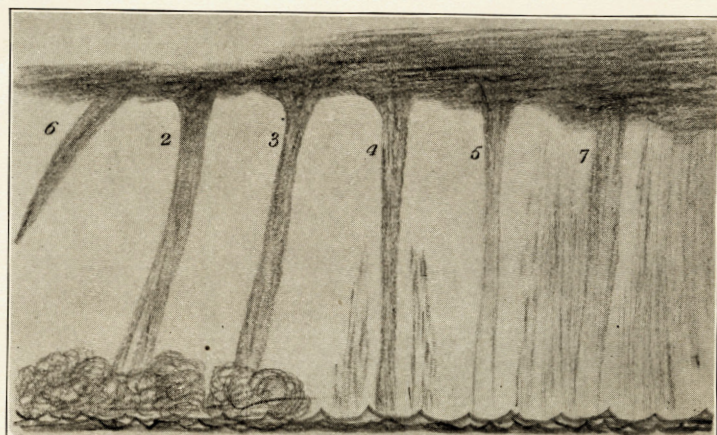
Nos. 1, 2, and 3 foaming at base. No. 6 is a convex spur,  $3^\circ$  long, growing into a waterspout.

Fig. 3.—Third phase, observed at 7:52 a. m.



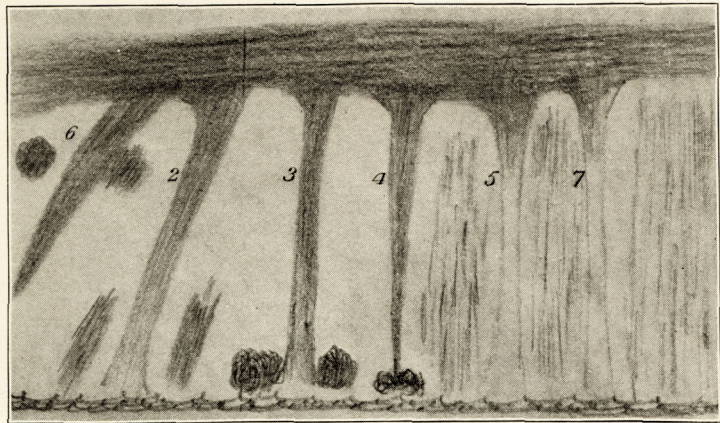
No. 2 leaning at an angle of  $45^\circ$  and the rising water at its base (seemingly) separate from the waterspout. No. 3 at an angle of  $50^\circ$  and a volume of water half way up the trunk and on each side of it but, seemingly, separate from the trunk. No. 6 growing slowly. No. 4 drawing up. Nos. 5 and 7 merely outlined.

Fig. 4.—Fourth phase, observed at 8:00 a. m.



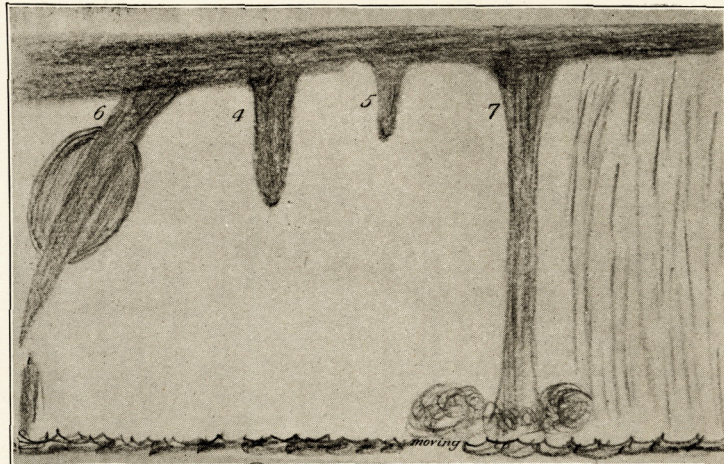
No. 1 has disappeared. Nos. 2 and 3 are at an angle of  $50^\circ$ . No. 4 has a volume of water on each side of column but not touching trunk. Nos. 5 and 7 have well-defined outlines and a considerable amount of water diffused between them.

Fig. 5.—Fifth phase, observed at 8:04 a. m.



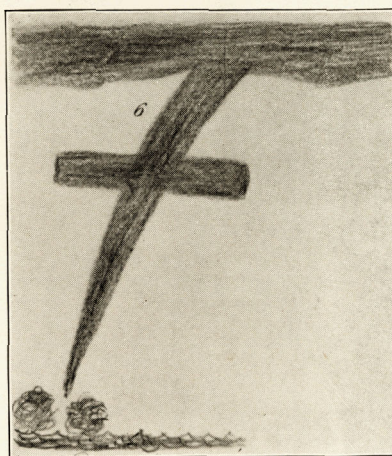
No. 6 still growing and a volume of water accumulated on each side of trunk. No. 2 still leaning about 50°. No. 4 was the only waterspout during the whole series that presented the typical pointed appearance; all the others were of uniform size. Nos. 5 and 7 have plain outlines, although the spaces between Nos. 4, 5, and 7 are quite misty.

Fig. 6.—Sixth phase, observed at 8:07 a. m.



At 8:06 No. 3 passed by No. 2 moving briskly but moving from the same direction which shows that there was a parallel current of air at the same time, but of greater force. In fifteen seconds after passing by No. 2, No. 3 disappeared; in fifteen seconds more No. 2 disappeared. No. 6 has water collected around the trunk in double convex form. Nos. 4 and 5 have drawn up and No. 7, well defined, has moved to the left.

Fig. 7.—Seventh phase, observed at 8:09 a. m.



No. 6 has taken the shape of a curved dagger; at no time did it reach to the sea, but the last two phases caused commotion in the water below it. Nos. 4, 5, and 7 have disappeared and the spout region has cleared. The last of this phenomena disappeared at 8:10 a. m.